

**DEVELOPMENT OF AN IMPROVED DOSE RECONSTRUCTION
SYSTEM FOR THE GENERAL POPULATION AFFECTED BY THE
OPERATION OF THE MAYAK PRODUCTION ASSOCIATION**

**Submitted to the Office of International Health Programs, U.S. Department of Energy
for the
US–Russia Joint Coordinating Committee on Radiation Effects Research**

Update on Project 1.1 Tasks and Milestones

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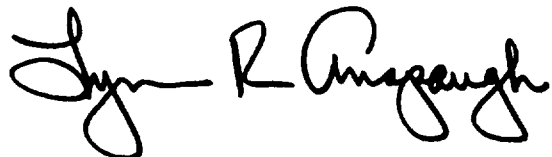
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INTRODUCTION

Several changes have been made in Project 1.1 as a result of the US–Russia meeting in Washington, DC, during February 1997. At that time there was a joint meeting of the US and Russian Scientific Review Groups (SRGs), and a main item of discussion was Project 1.1. A specific purpose was to attempt resolution of conflicting recommendations of the Russian and American SRGs about the dose-reconstruction methods for and the participants in Project 1.1.

In the opinion of the authors of this report, the primary results from this meeting were:

- Approval was given to proceed with the upgrade of the URCRM Whole-Body Counter. This unique counter is designed primarily to count the bremsstrahlung emissions from ^{90}Sr and daughter ^{90}Y , but also can be used to measure body content of gamma-emitting radionuclides.
- The SRGs recommended that more emphasis be given to obtaining tooth samples, for later measurements of dose by electron paramagnetic resonance, from members of the Techa River Cohort. Particular emphasis was to be placed on the residents of the upper Techa who would be subject to larger external gamma doses.
- Members of the American SRG desired more work be done on the reconstruction of source terms, although most members of the Russian SRG did not think this to be useful. Members of the Mayak Production Association (MPA) attended this meeting and made a presentation wherein they proposed further work on a river model that might be used to derive a source term. The decision was reached to separate this activity from Project 1.1 and to form a new Project 1.3 for this purpose. This new Project 1.3 will be led by members of the MPA for the Russian side, whereas the Russian leadership of Project 1.1 will be solely with the Urals Research Centre for Radiation Medicine (URCRM).

These results have been implemented through a variety of processes. The main ones are:

- As the source-term development has been removed from Project 1.1 and transferred to new Project 1.3; Dr. Evgenii Drozhko of the MPA will no longer be one of the Principal Investigators of Project 1.1, and the MPA will no longer be one of the Participating Institutions for Project 1.1.
- Task 1 and Subtask 1 on “Source-term review (E. Drozhko)” has been replaced with a new Task 1 and Subtask 1 on “Feasibility analysis of the development of a special system for obtaining tooth samples from the Techa River residents (M. Degteva).”
- Associated Milestone 5 on “Report on the review of the releases to the Techa River during the 1949–1952 period” has been replaced with “Report on the feasibility analysis of the development of a special system for obtaining tooth samples from the Techa River residents.”

In addition several minor changes have been made, and real dates have been added now that there is an actual start date of February 1997 for Project 1.1.

REVISED LIST OF TASKS AND SUBTASKS

The goal of this study is to improve the system for the reconstruction of external and internal radiation doses for 34,000 individuals belonging to the Techa River Cohort. The purpose of the dose reconstruction is to support companion epidemiologic studies of radiogenic leukemia and solid cancers. The objectives of the work to be carried out within the framework of this project can be divided into two broad work packages.

- Work package 1 is the improvement in dose reconstructions based on further analysis of the data available and the further development of the Techa River Dosimetry System.
- Work package 2 is the development of improved methods of instrumental retrospective dosimetry (Electron Spin Resonance, Thermoluminescence Dosimetry, Whole-body Counting, etc.) in order to validate the doses calculated.

Specific Tasks for Work Package 1: Techa River Dosimetry System Improvements

Task 1. Feasibility analysis of the development of a special system for obtaining tooth samples from the Techa River residents (M. Degteva).

Subtask 1. Examine the feasibility of establishing a system of tooth collection for the members of the Techa River Cohort. This system should be oriented toward the collection of teeth as they are being extracted for dental health purposes. A special aim would be the collection of teeth from former residents in the Upper Techa River locations that have long since been evacuated.

Task 2. Source-term and environmental data analysis (M. Vorobiova).

Subtask 2. Check the consistency of available source-term and historical monitoring data in order to verify and confirm limited available information on the source term.

Subtask 3. Develop a simple empirical river model in order to verify distance dependence of radionuclide composition of river water and to link radionuclide concentrations in water and bottom sediments with γ -exposure rates on the banks near the river.

Task 3. External dose reconstruction (D. Burmistrov)

Subtask 4. Verify γ -exposure rates on the banks near the river and validate accumulated doses calculated on the basis of verified γ -exposure rates in specific points of the upper and middle Techa by the results of thermoluminescent measurements in bricks from the same sites.

Subtask 5. Enter into computer and analyze available data on the outdoor and indoor γ -exposure rates on the territories of the Techa Riverside settlements in order to determine the dependence of γ -exposure rate from the distance from the edge of the water and to verify the contributions to the total external dose from the sources of radiation exposure in the streets, gardens, and houses.

Subtask 6. Evaluate organ-specific absorbed doses from external exposure (based on literature data) and include these values into the TRDS system code.

Subtask 7. Validate absorbed doses in individuals from external sources of radiation by the results of electron paramagnetic resonance measurements in teeth.

Task 4. Internal dose reconstruction (V. Kozheurov and E. Tolstykh).

Subtask 8. Verify radionuclide-ingestion levels derived from the results of river modeling (Subtask 3) and include into TRDS Module 1 the ingestion levels of other radionuclides from the releases (Zr, Nb, Ru, Ce, etc.).

Subtask 9. Include into TRDS Module 2 appropriate metabolic and dosimetric model calculations (based on literature data) for other radionuclides according to the results of Subtask 8.

Task 5. Uncertainty analysis (M. Degteva)

Subtask 10. Enter into computer "interview data" (source of drinking water, the distance of the house from the edge of water etc.) for the residents of two Techa Riverside villages: Metlino and Muslyumovo.

Subtask 11. Develop an algorithm of classification (grouping) of the persons belonging to "families" (households) according to the source of drinking water and/or the distance from the edge of water based on individual-strontium measurements, family-member lists (available in data base MAN) and interview data (Subtask 10).

Subtask 12. Perform the grouping of persons according to the algorithm from Subtask 11 for the residents of Metlino and Muslyumovo villages. Evaluate "inside group" and "between groups" contributions into variation for internal dose (based on whole-body counter measurements). Evaluate the feasibility of estimating the contributions to external dose uncertainties from the distance of the house from the river and individual variability in behavioral regimes

Subtask 13. Evaluate the contributions to internal dose uncertainties from the source of drinking water (river or wells) and individual variability in diet habits and metabolic parameters on the basis of Metlino and Muslyumovo data.

Subtask 14. Evaluate the feasibility of the reconstruction of household specific doses for the entire Techa River Cohort on the basis of the results of Subtasks 12 and 13. Develop a plan for further study on dose reconstruction.

Specific Tasks for Work Package 2: Instrumental Dosimetric Method Developments

Task 6. Whole-body-counter calibration and modification (V. Kozheurov and A. Kovtun).

Subtask 15. Manufacture an anthropomorphic physical phantom of the body of an adult with an uniform distribution of ^{90}Sr in the skeleton. This phantom will be used for the recalibration of whole-body counter SICH-9.1. The design of this phantom was described in the Final Report of JCCRER Project 1.1 (Degteva et al. 1996).

Subtask 16. Prepare the protocol and perform the calibration of whole-body counter SICH-9.1 for ^{90}Sr , ^{137}Cs and ^{40}K using special phantoms. Evaluate instrumental errors for SICH-9.1 in order to provide better verification of the thousands of whole body counts available at the URCRM.

Subtask 17. Develop a mathematical phantom to simulate the spectral and angular distribution of photon radiation, including bremsstrahlung, at the surface of the phantom resulting from the radioactive decay of incorporated radionuclides in order to study the effects of non-uniform distribution of ^{90}Sr in the different bones and structures of the skeleton and to study the effects of variations in individual-body geometry.

Subtask 18. Develop the design for modification of SICH-9.1 and perform the upgrade of SICH-9.1 in order to replace obsolete detectors and electronics and provide continuity of whole body measuring.

Task 7. Electron paramagnetic resonance (EPR) measurements (A. Romanyukha).

Subtask 19. Perform about 90 measurements of teeth for the residents of the middle Techa in order to evaluate age dependence of EPR signal for exposed people and compare individual external doses based on these measurements with the results of calculations (Subtask 7).

Subtask 20. Perform about 90 measurements of teeth for the residents of non-contaminated areas of the Ural Region in order to evaluate age dependence and the nature of background EPR signal.

Task 8. Luminescence measurements (N. Bougrov).

Subtask 21. Perform TL measurements for about 7–10 sites in Muslyumovo Settlement in order to evaluate the distribution of radiation fields and to compare external doses based on these measurements with the results of calculations (Subtask 4).

REVISED LIST OF MILESTONES AND DELIVERABLES

1. Analytical review of historical environmental and source-term monitoring data and modeled concentrations of radionuclides in Techa River water and sediments at specified locations over time. Includes description of hydrologic data and models employed.

(Task 2) -- October 1997.

2. Protocol of the calibration of whole-body counter SICH-9.1 for ^{90}Sr , ^{137}Cs and ^{40}K using special phantoms.

(Subtasks 15 and 16) -- February 1998.

3. Report on individual-body-burden histories and resulting internal organ doses evaluated on the basis of the Techa River Dosimetry System approach. Includes doses due to all radionuclides ingested.

(Task 4) -- August 1998.

4. Report on environmental thermoluminescent dosimetry measurements and its comparison with values calculated on the basis on historical monitoring data.

(Task 8 and Subtask 4) -- November 1998.

5. Report on the feasibility analysis of the development of a special system for obtaining tooth samples from the Techa River residents.

(Task 1) -- July 1997.

6. Report on external organ doses evaluated on the basis of Techa River Dosimetry System approach.

(Subtasks 4 and 6) -- February 1999.

7. Description of mathematical phantom for ^{90}Sr .

(Subtask 17) -- February 1999.

8. Description of data base and algorithm for classification (grouping) of Techa River residents according to "family groups" in dependence of house position relative to the river and/or the source of drinking water.

(Subtasks 10 and 11) -- May 1999.

9. Report on individual external doses measured for specific individuals using EPR and comparison with calculated values.

(Subtasks 7, 19, and 20) -- August 1999.

10. Completion of upgrade of the SICH-9.1 whole body counter.

(Subtask 18) -- November 1999.

11. Final report on uncertainties in Techa River Dosimetry System and the feasibility of further individual-dose verification.
(Subtasks 12, 13 and 14) -- February 2000.

DISCUSSION

The dates listed above for the deliverables of the project are flexible and some are dependent upon external events. For example, if the ^{90}Sr phantom can be delivered in a reasonable time period and if the upgrade for the detector system and electronics for the URCRM whole body counter can be achieved on an expedited schedule, it may be possible to deliver milestones 7 and 10 ahead of schedule.

We also anticipate that it will be desirable to make further refinements in the task descriptions for Task 7 (Subtasks 19 and 20). Now that the feasibility of a tooth-collection system has been established, we plan to implement this system. However, implementation does not make sense unless there is greatly increased available measurement time on a sophisticated EPR spectrometer. At the present time there is no such spectrometer in the Urals region. Work will continue on borrowed time on other spectrometers in Munich and Salt Lake City, but the purchase of a new spectrometer for the Institute of Metal Physics would greatly facilitate the amount of work that can be done and its timeliness for this project. If tooth samples are successfully collected from the upper Techa River residents, the tooth samples should be analyzed on a continuing basis beginning in early FY 1998. The current description of Task 7 lists 90 measurements of teeth from residents of the middle Techa and 90 measurements of teeth from residents in non-contaminated areas. It would be desirable to add about 50 measurements of teeth from upper Techa River residents, if the tooth-collection system can be implemented and if an EPR spectrometer can be purchased for the Institute of Metal Physics.

In addition to the milestones indicated above more specific milestones were attached to the funding agreement for the URCRM for February 1997 through October 1997. These milestones are the following

1. Justification of the equipment for the whole-body counter (SICH-9.1) upgrade (May 1997).
2. Feasibility analysis of the development of a special system for obtaining tooth samples from Tech River residents (July 1997).
3. Analytical review of historical monitoring data and modeled concentrations of radionuclides in Techa River water and sediments at specified locations over time. Includes descriptions of hydrologic data and models employed (October 1997).
4. Manufacturing of an anthropomorphic phantom for calibration of the whole-body counter SICH-9.1 (October 1997).

The above Milestone 1 is considered to be fulfilled. The need for Milestone 1 came from questions raised by one member of the American SRG. Upon further discussion it is our understanding that this issue has been resolved informally, and there is no need for a written report on this subject.

Milestone 2 above will be completed with the submission of a report in July 1997. This milestone is equivalent to Milestone 5 in the master list.

Milestone 3 above will be completed with the submission of a report in October 1997. This milestone is equivalent to Milestone 1 in the master list.

Milestone 4 above depended upon the administrations of the URCRM and the Institute of Marine Transport Hygiene (IMTH) implementing a contract. The scientific input for such a contract was provided two months ago. This contract was signed by both parties as of 26 June. However, the manufacture of this phantom will require six to eight months; thus, it is now impossible to meet the above Milestone 4 on time. If the contract is successfully implemented by July 1997, then Milestone 4 might be completed in the January–March 1998 time frame. This delay will impact the completion of Milestone 10 from the master list, although completion of Milestone 10 is still expected to be accomplished on or before schedule.

REFERENCE

M.O. Degteva, E. Drozhko, L.R. Anspaugh, B.A. Napier, A.C. Bouville, C.W. Miller, Ed., *Joint Coordinating Committee on Radiation Effects Research, Project 1.1–Final Report, Dose Reconstruction for the Urals Population*, Lawrence Livermore National Laboratory, CA, UCRL-ID-123713 (1996).